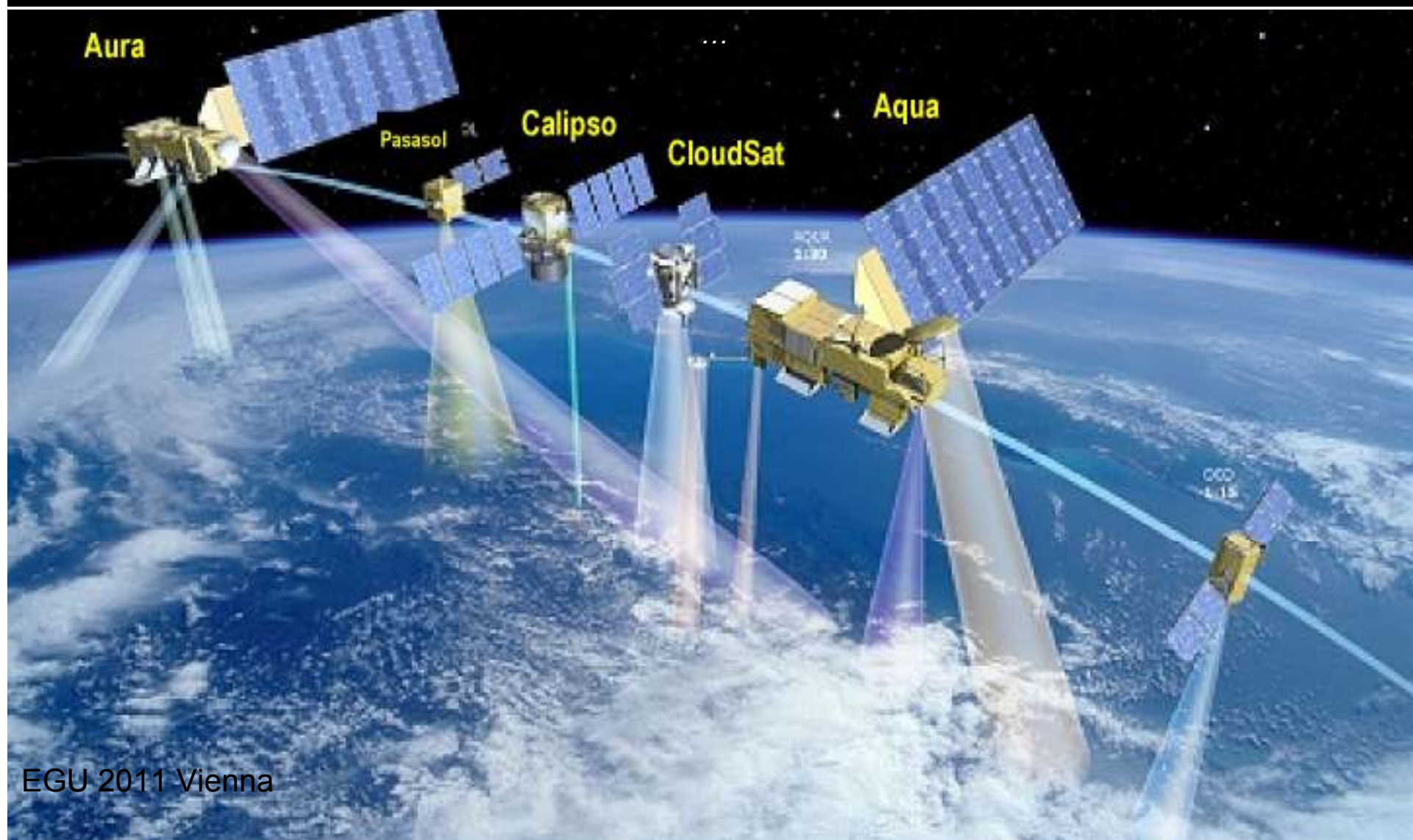


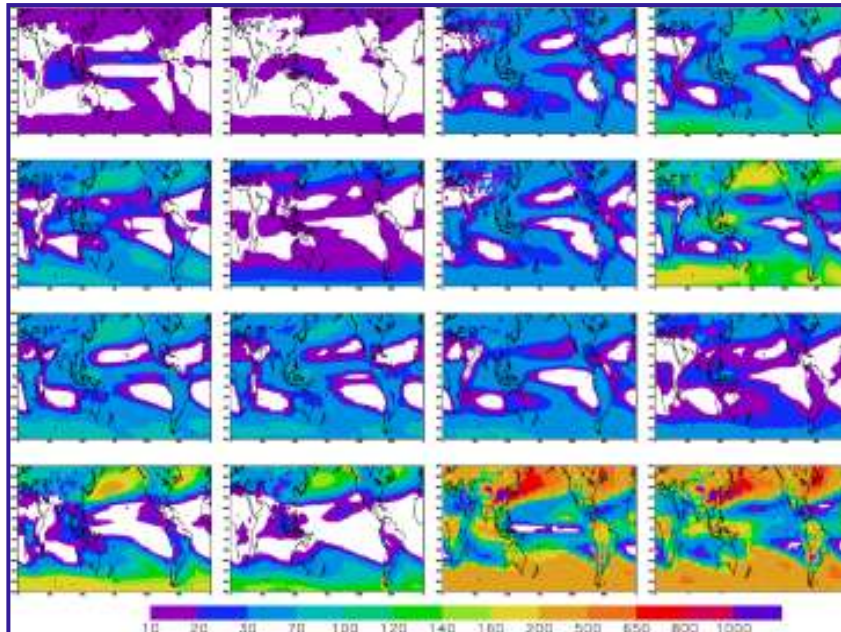
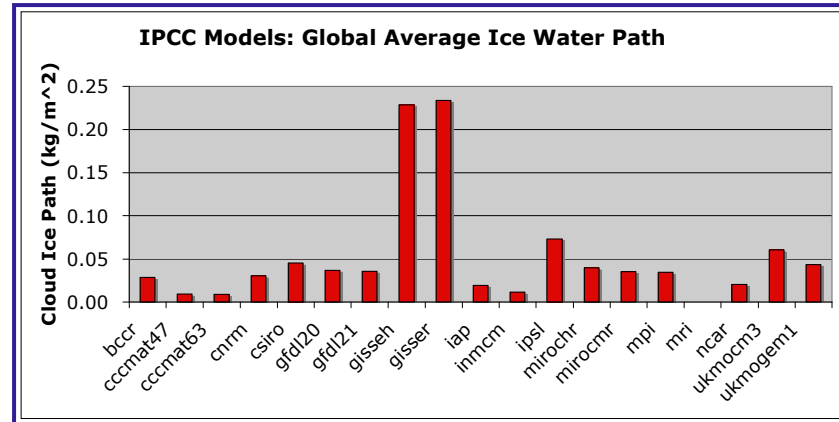
Model Evaluation of Ice/Liquid Water Content, Radiation and Energy Budget for 20th Century Simulations for IPCC 4th and 5th for Assessment Reports

*Jui-Lin F. Li/JPL, Duane Waliser/JPL,
Tristan L'Ecuyer/UW, Graeme Stephens/JPL, B. Guan/JPL, Richard Forbes/ECMWF, H-Y Ma/LLNL, Ann
Chen/JPL*



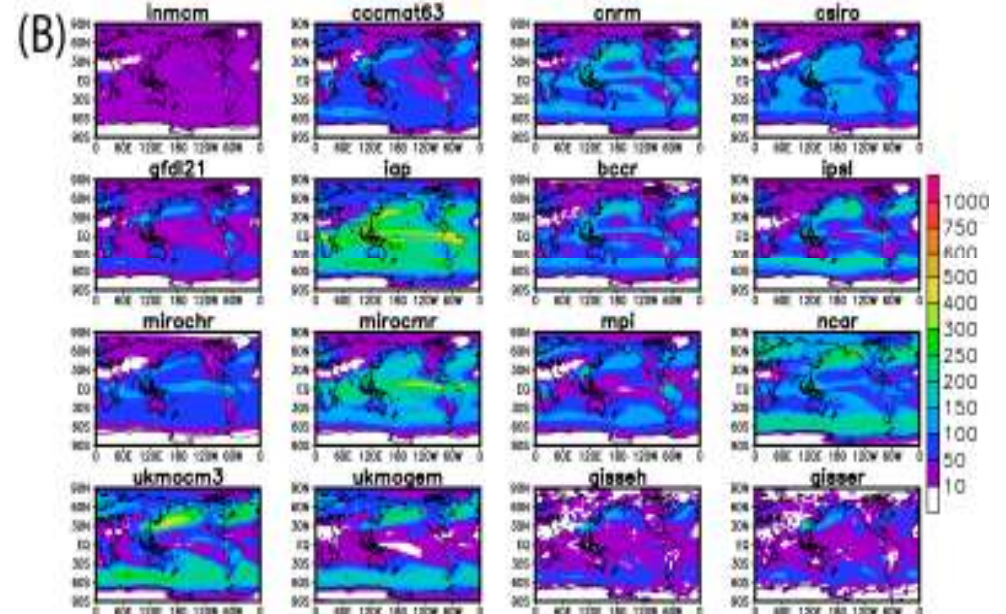
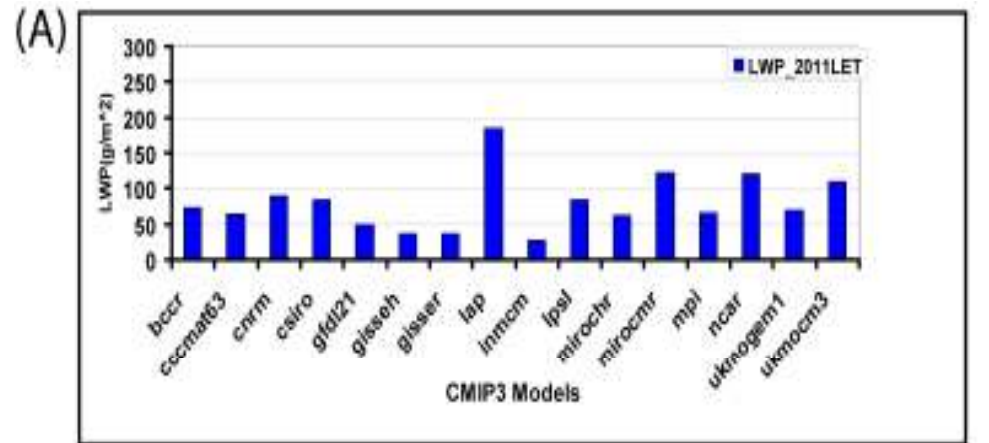
IPCC CMIP3 Model Uncertainties: “Cloud Ice & Liquid”

IWP



(Waliser and Li et al, 2009)

LWP

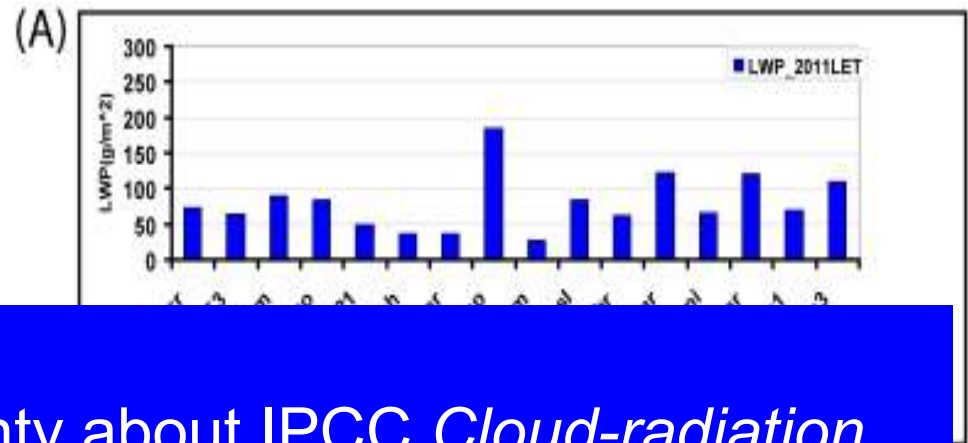
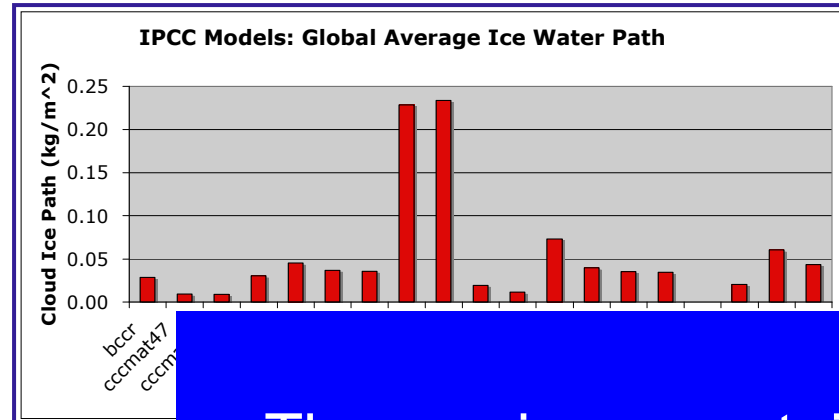


(Li et al, 2008; 2011)

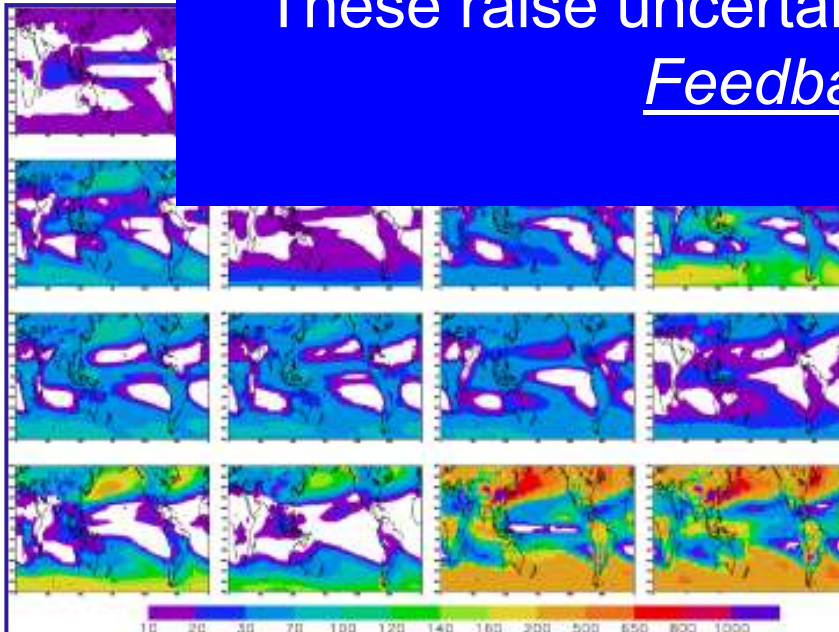
IPCC CMIP3 Model Uncertainties: “Cloud Ice & Liquid”

IWP

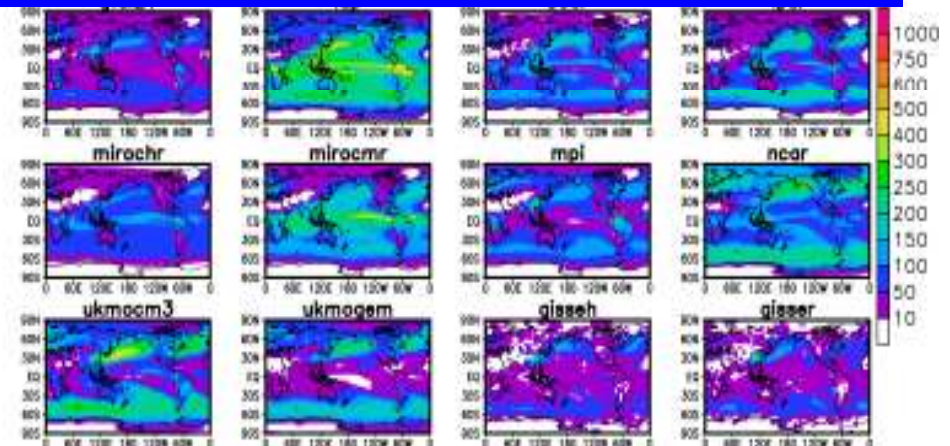
LWP



These raise uncertainty about IPCC Cloud-radiation Feedback representation

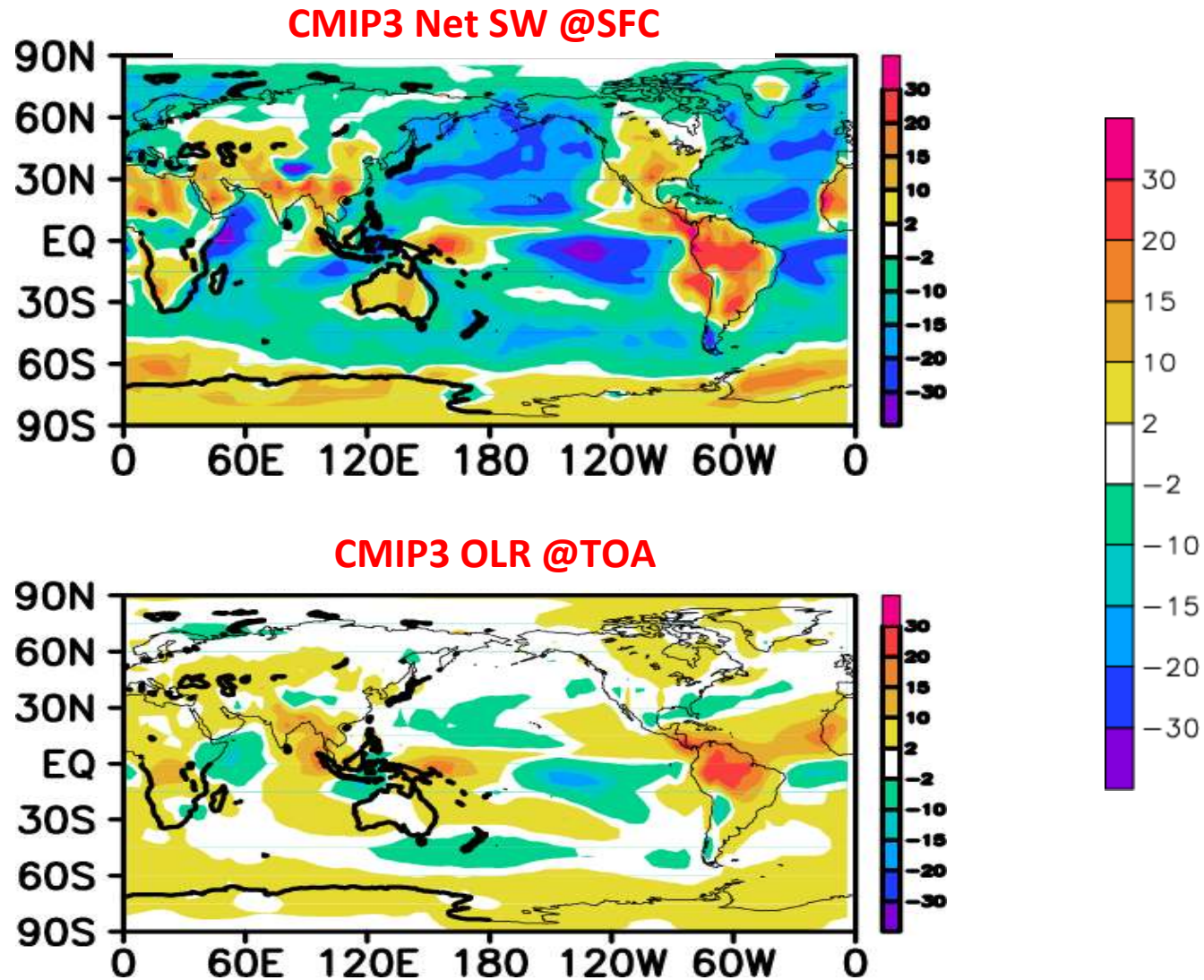


(Waliser and Li et al, 2009)



(Li et al, 2008; 2011)

Annual Mean Present Climate CMIP3 Radiation Bias vs CERES/SRB



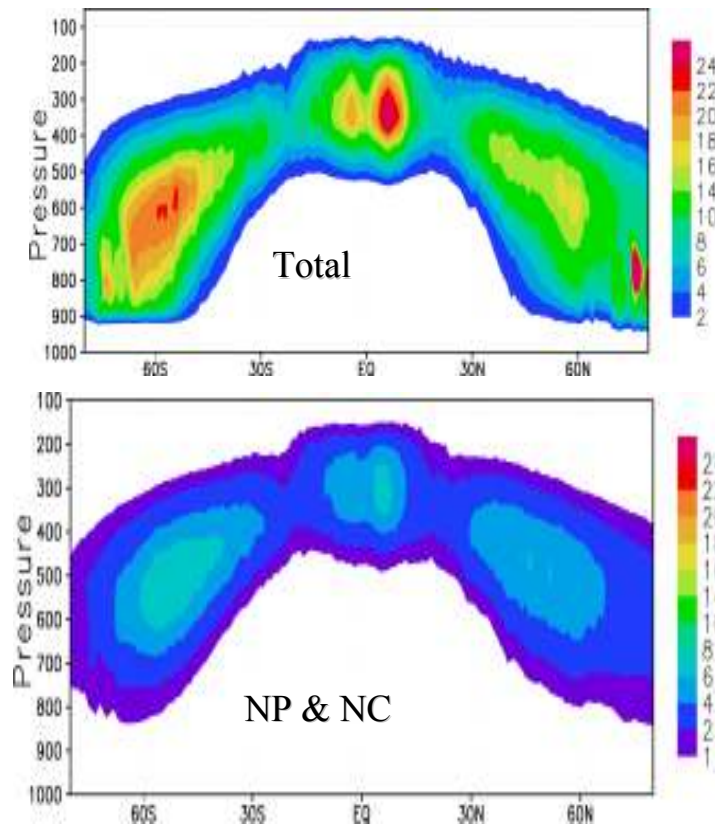
(Trenberth et al., 2009; Li et al., 2011c, in preparation)

- Precipitating and convective core cloud hydrometeors and their radiative effects are generally ignored in global climate models (GCMs) such as those used in CMIP3 & CMIP5 (Li et al., 2008; Waliser et al., 2009; Chen et al., 2011; Waliser et al., 2011)

Observed Cloud Ice and Liquid Water Content for Model-Data Evaluation

Methods to estimate observed cloud ice water content (CIWC) and cloud liquid water content (CLWC) from CloudSat and/or Calipso:

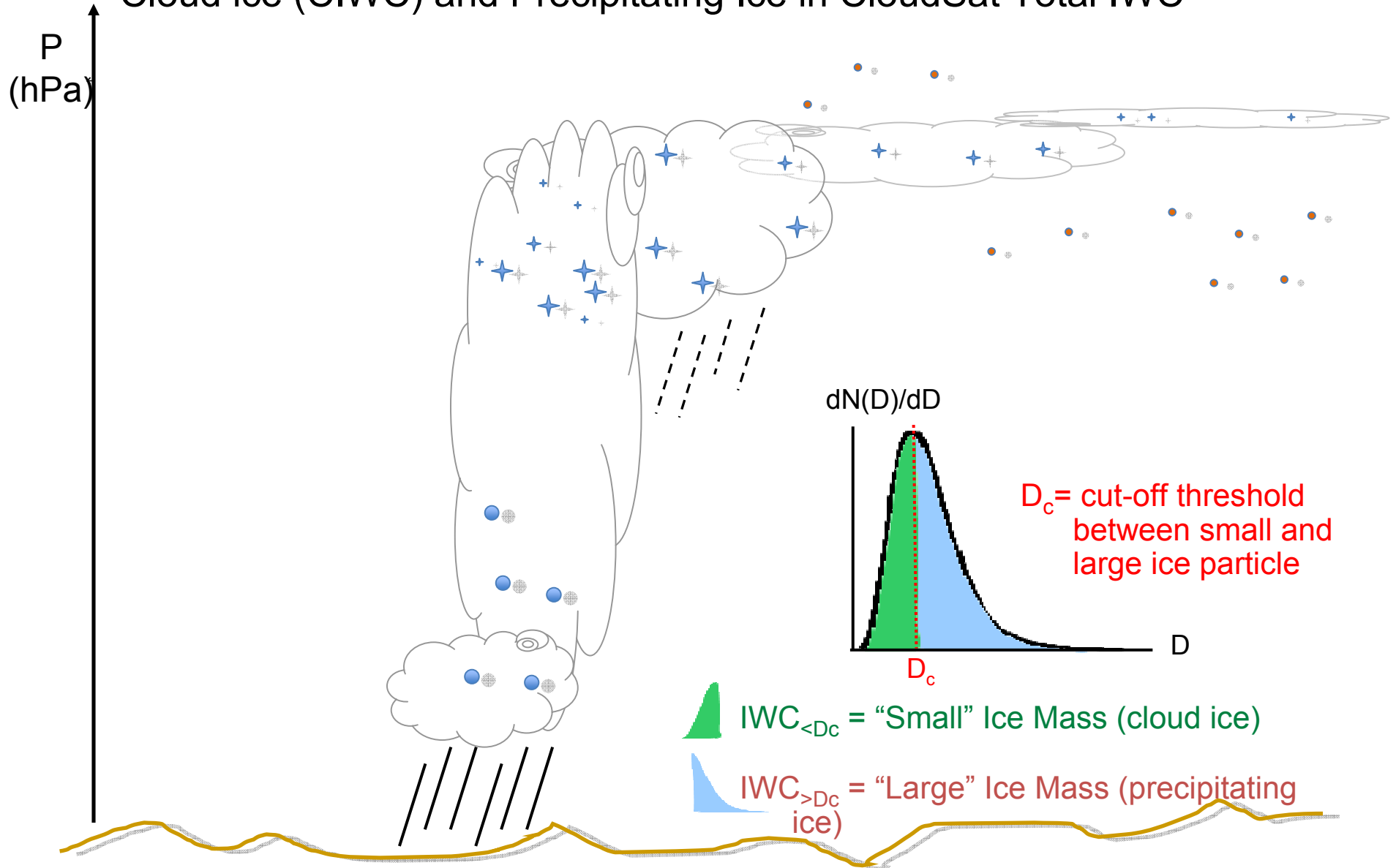
- **FLAG method** - Methods used to filter out cloud hydrometers using flags with convective & precipitation cases & column information to get ballpark estimates of CIWCL & CLWC for use in IPCC model evaluation ((Li et al., 2008; Waliser et al., 2009)



Filtering out convective clouds and precipitating cases we can get as a *preliminary* estimate of ice in clouds (*albeit this has shortcomings*)

(Waliser et al, 2009; Li et al., 2008)

PSD method - Using CloudSat Specified PSD information Separate Cloud ice (CIWC) and Precipitating Ice in CloudSat Total IWC

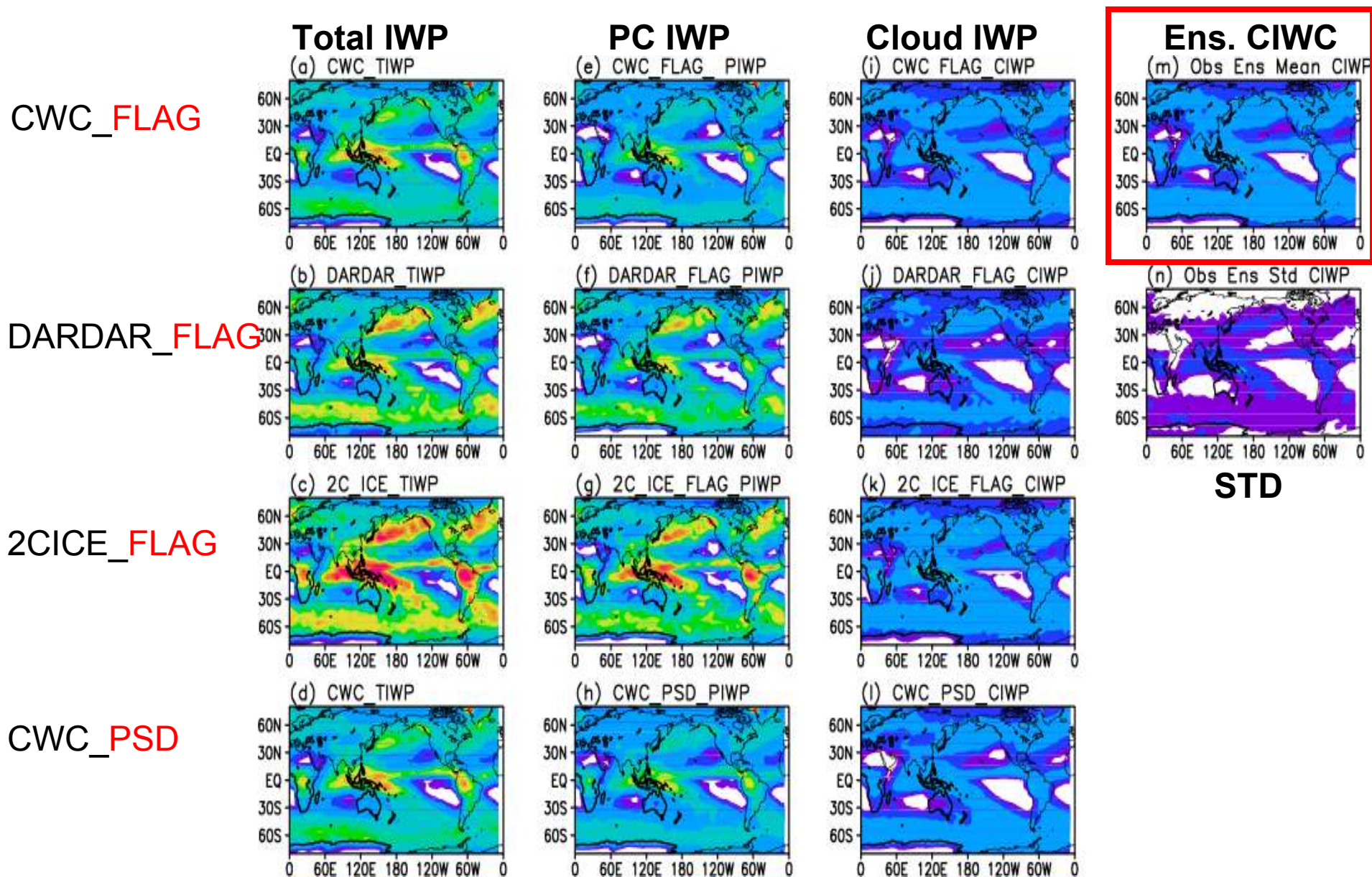


(Chen et al., 2011)

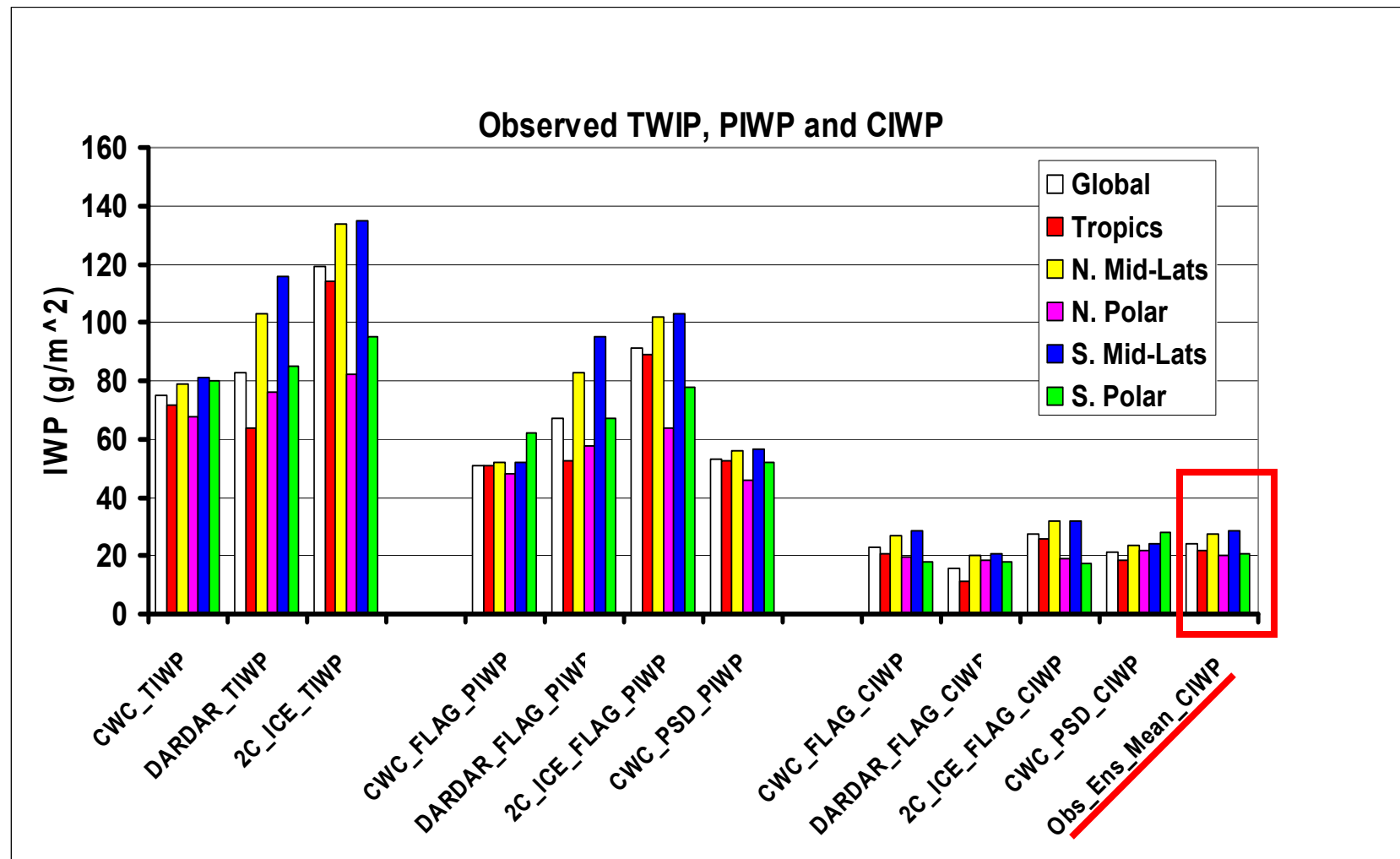
Observed Ice Water Data Used:

1. **CWC** - CloudSat Radar Only (Standard CloudSat product)
2. **DARDAR** - CloudSat Radar +CALIPSO Lidar combined products (Delanoe et al., 2010)].
3. **2CICE** - CloudSat Radar +CALIPSO + MODIS Lidar combined products (Deng, 2011)

Observed Cloud Ice Content (CWIP) for Model-Data Evaluation

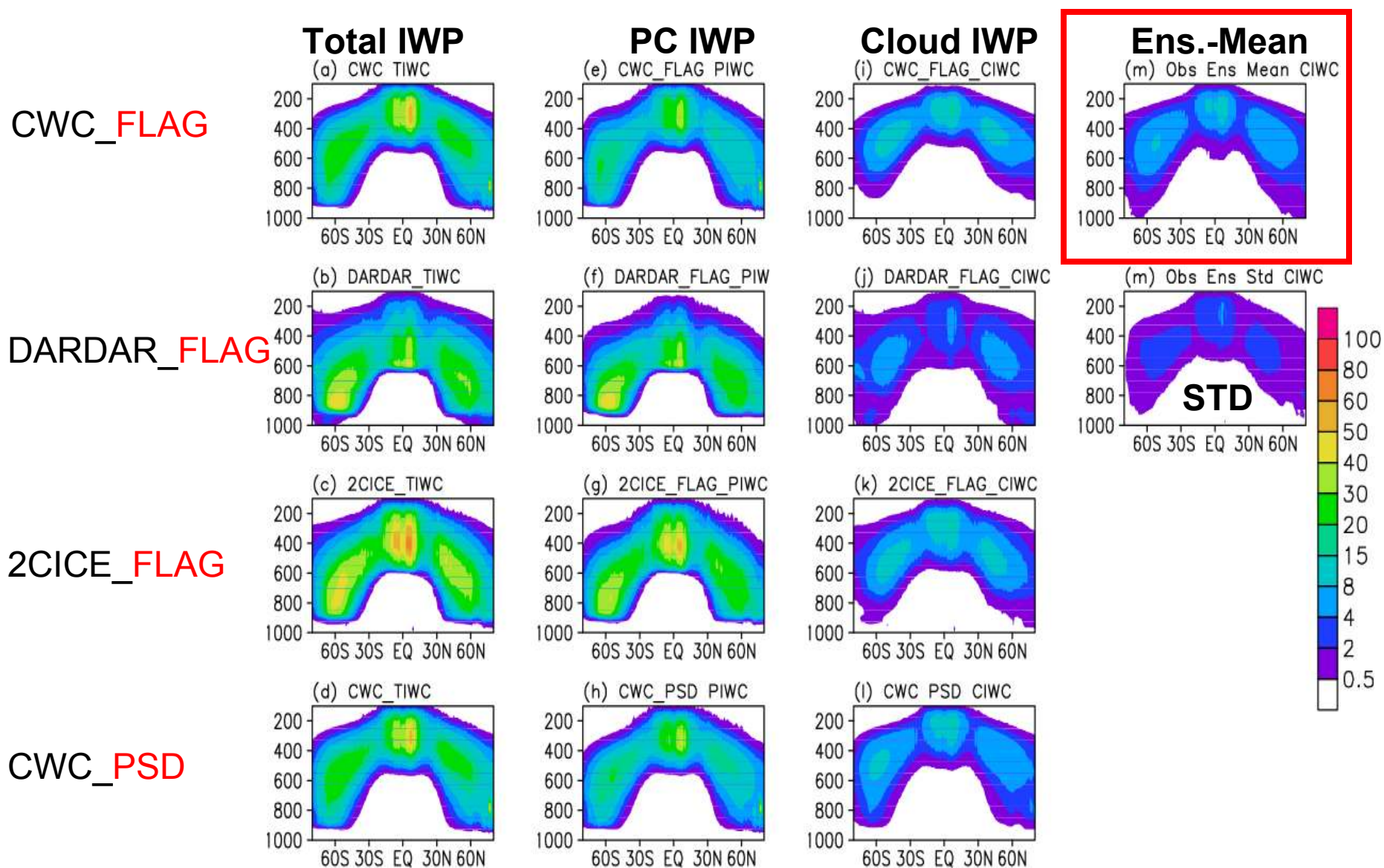


(Li et al., 2011a, in preparation)



(Li et al., 2011a, in preparation)

Observed Cloud Ice Content (CWIP) for Model-Data Evaluation

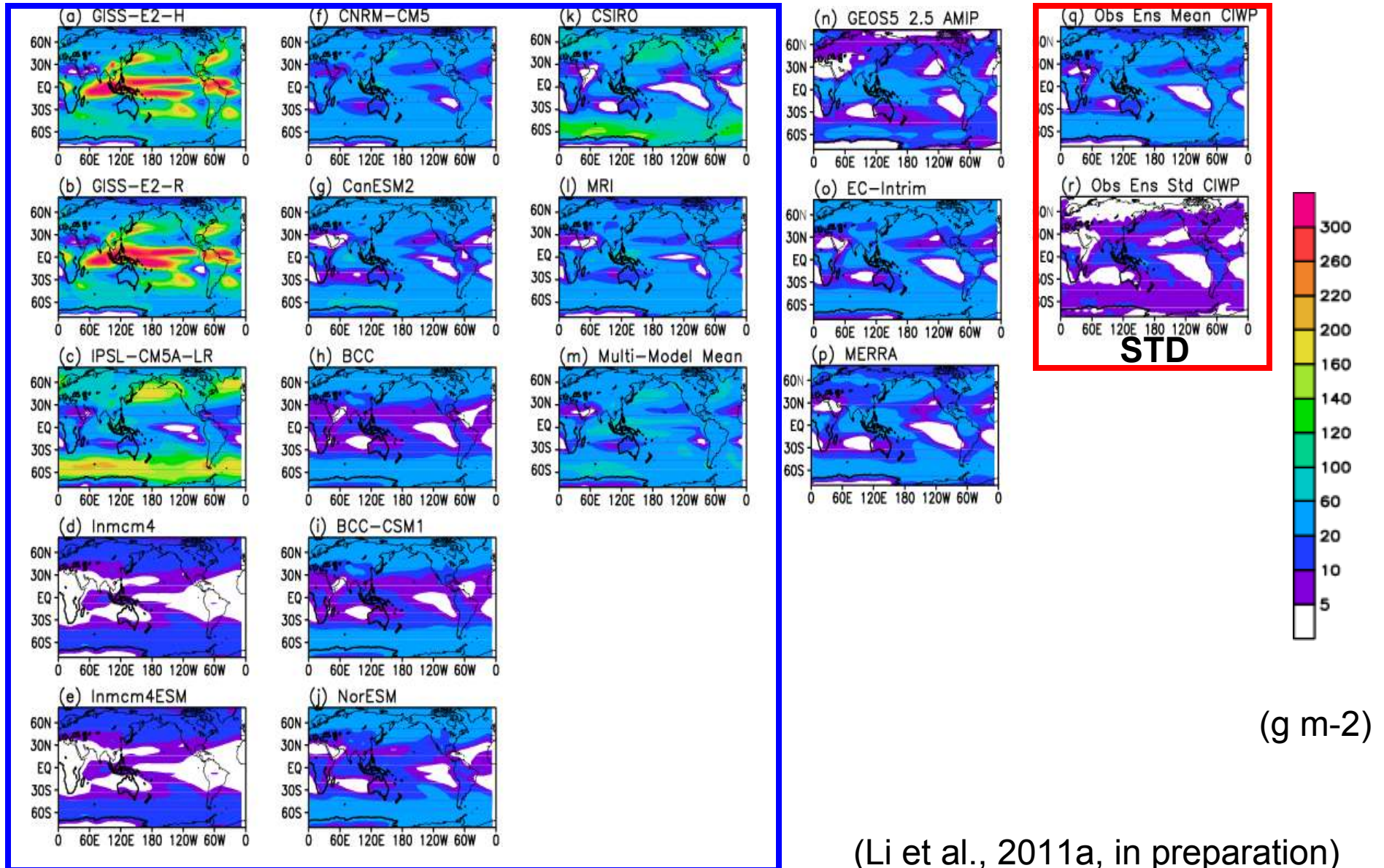


(Li et al., 2011a, in preparation)

IPCC CMIP5 Model Uncertainties: “Cloud Ice water Path- IWP”

CMIP5

AGCM & RA Obs. Mean CIWP

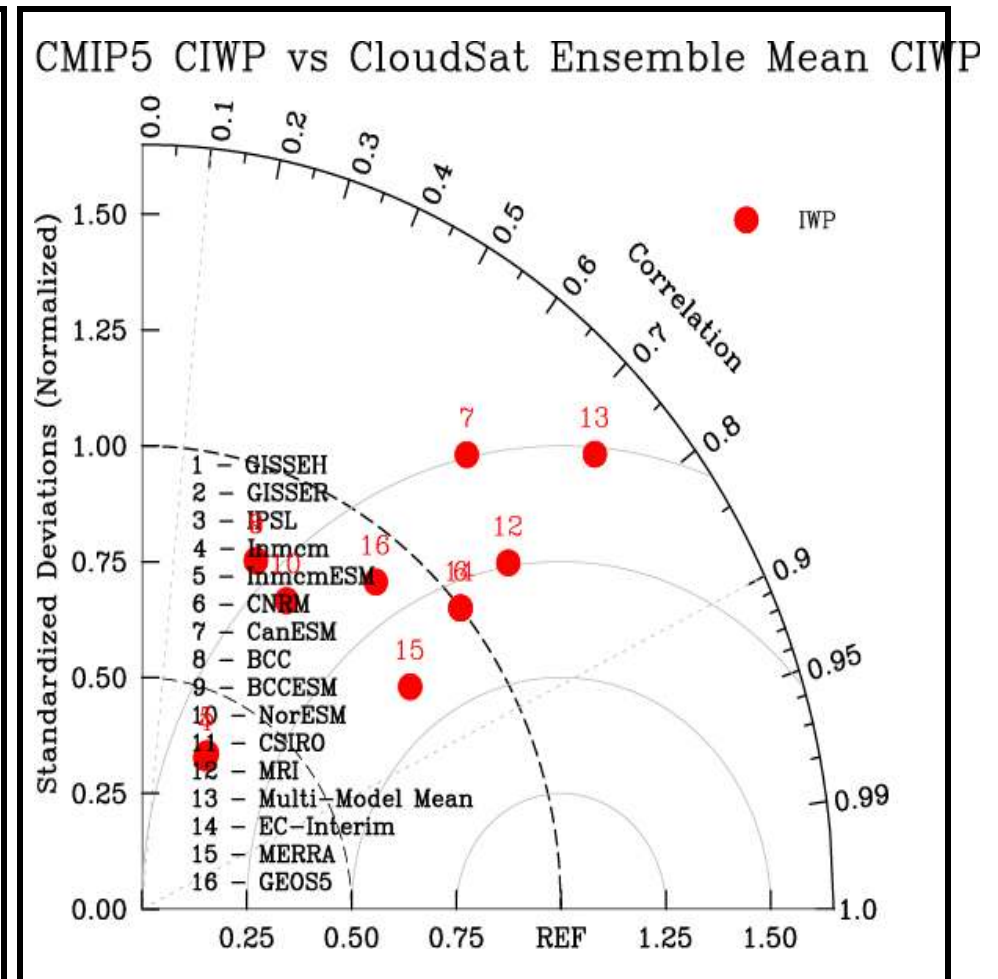
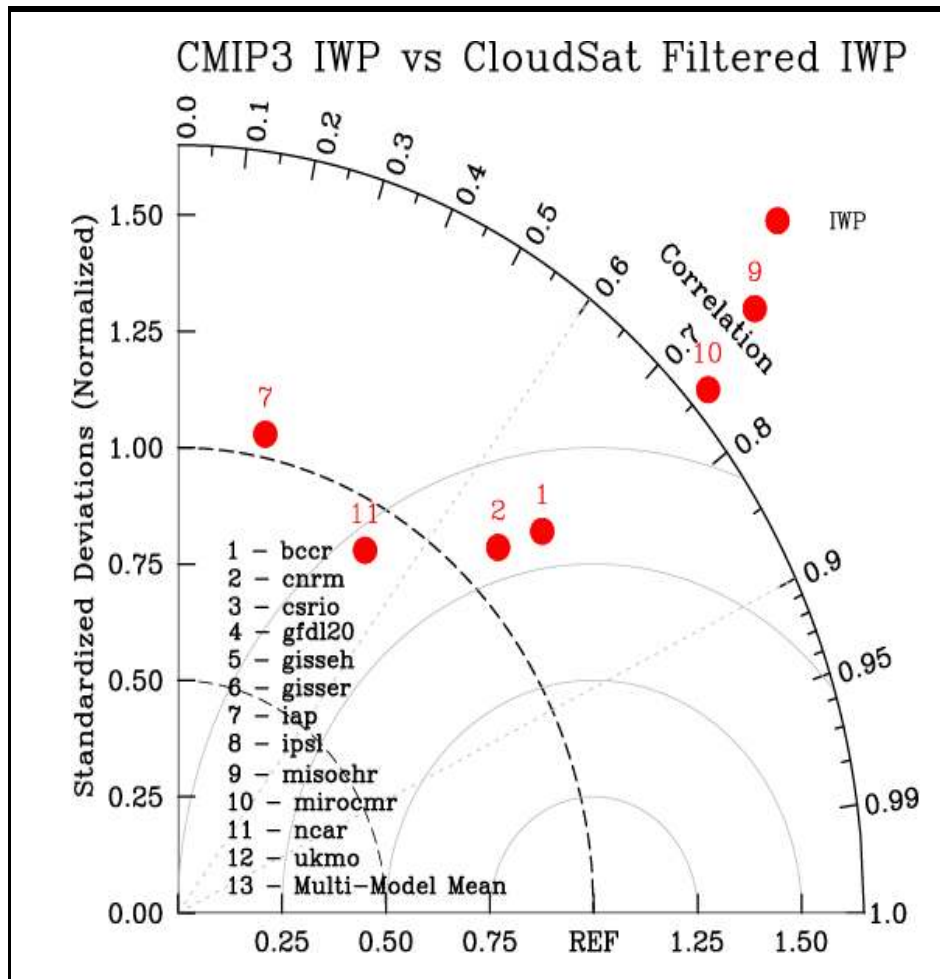


(Li et al., 2011a, in preparation)

Quantifying and Summarizing the Results

Taylor diagrams of global annual mean CMIP3 vs CMIP5 CIWP

Some but little improvement over CMIP3 evident



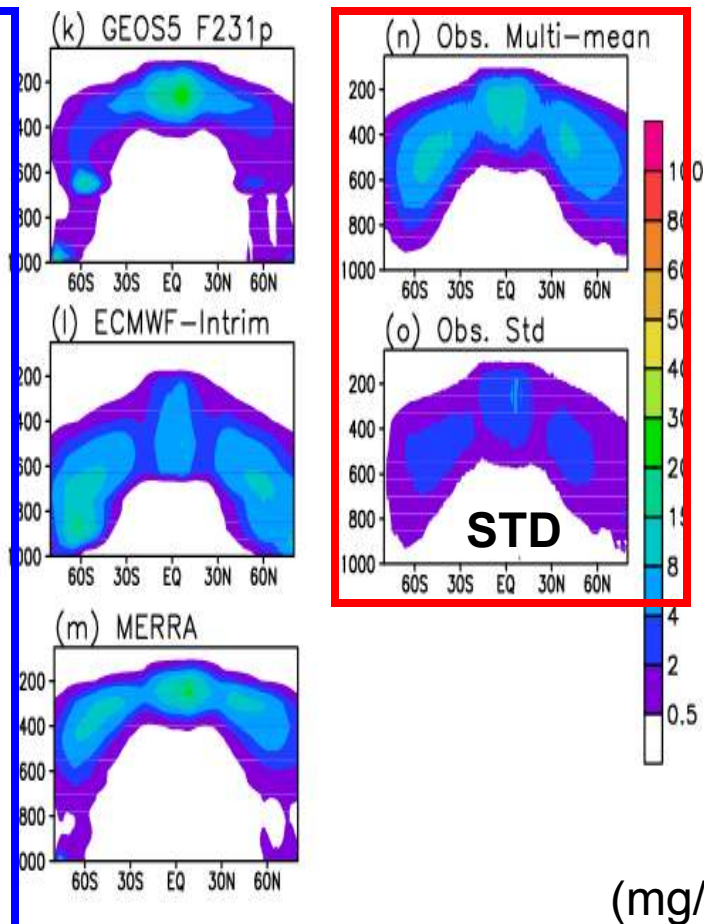
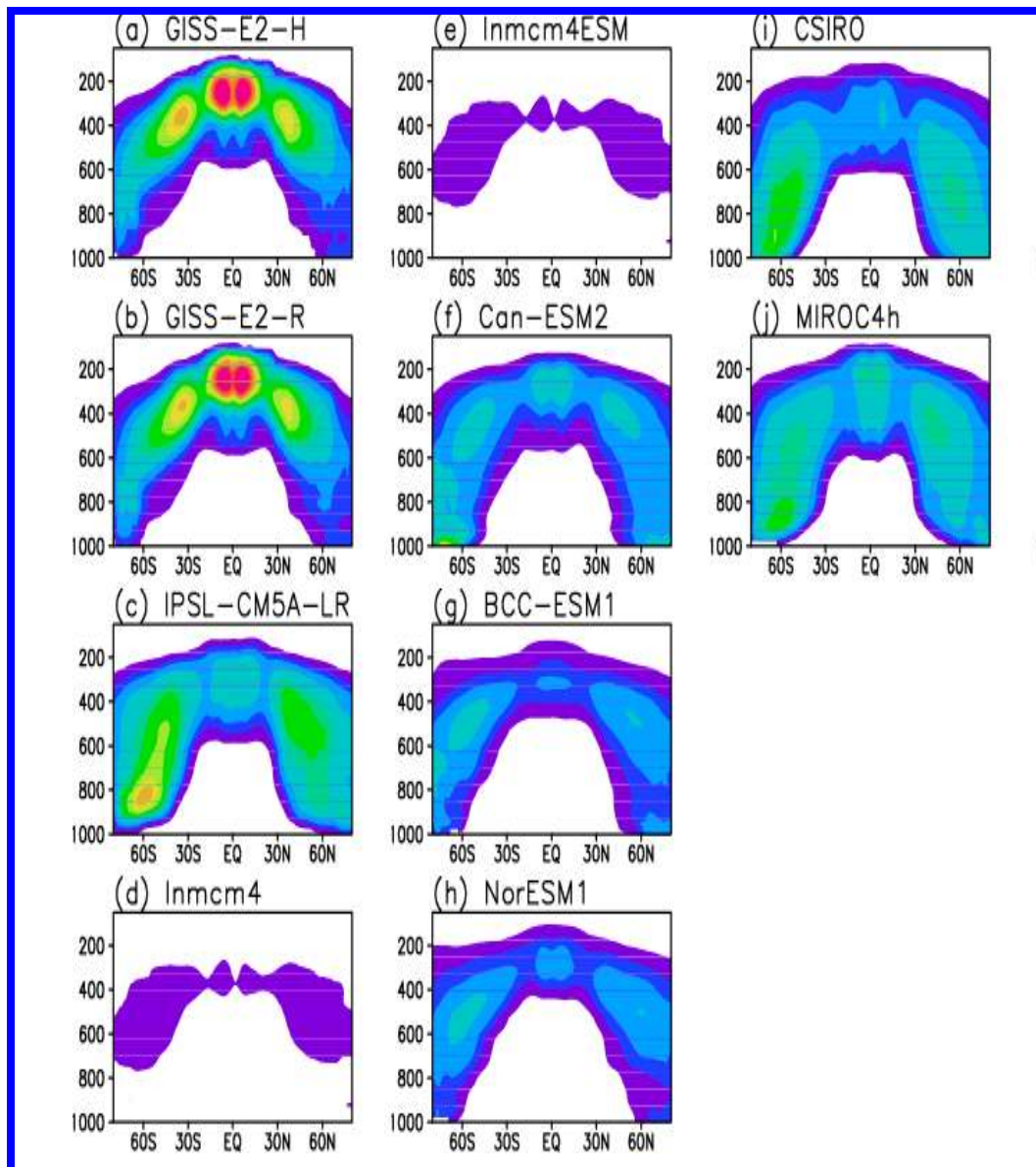
For models with standard ratio that exceed 1.75 are not shown in the Taylor diagram.

(Li et al., 2011a, in preparation)

IPCC CMIP5 Model Uncertainties: “Cloud Ice Water Content- CIWC”

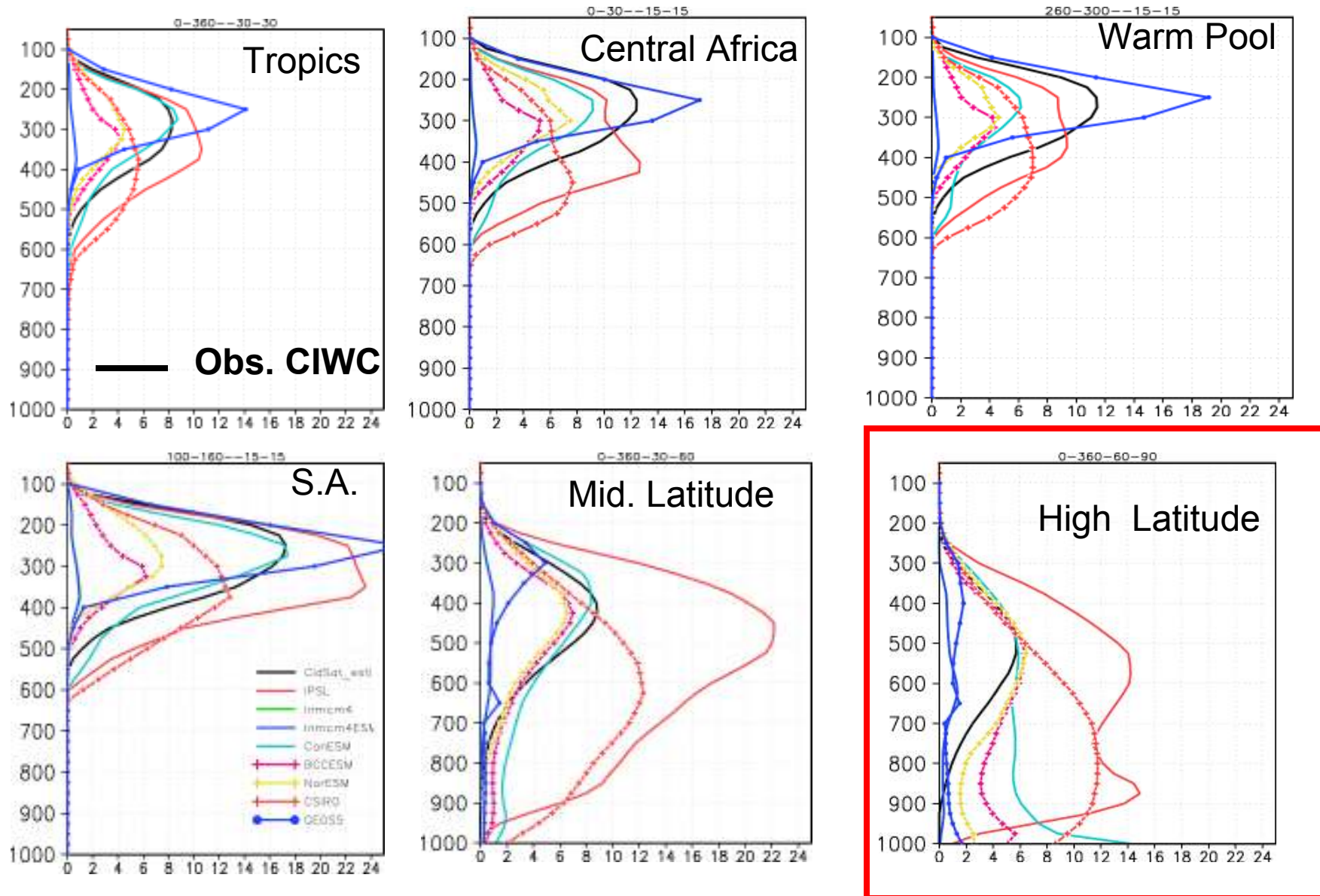
CMIP5

AGCM & RA Ens Mean Obs.



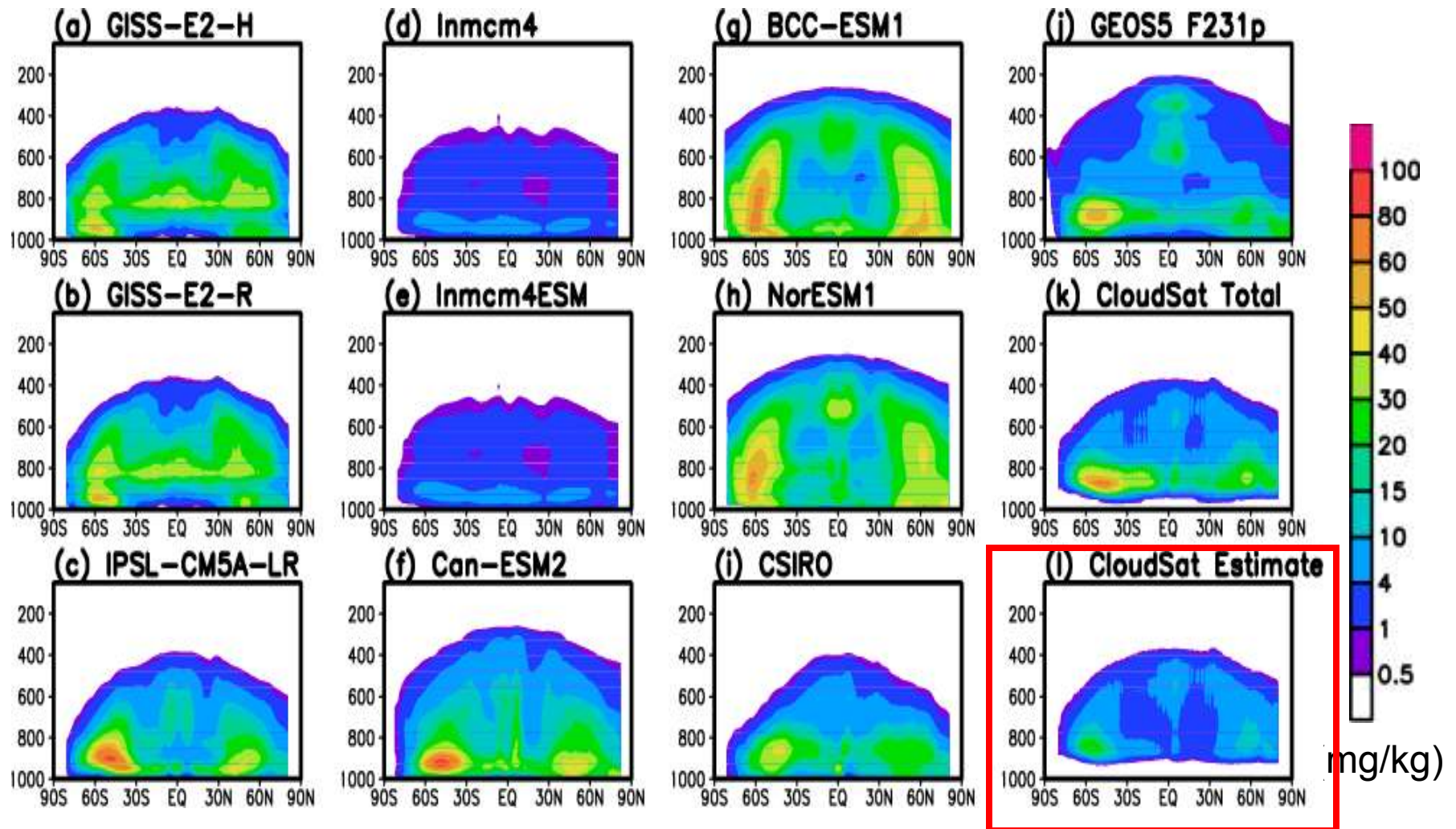
(Li et al., 2011a, in preparation)

Regional Annual Mean CMIP5 CIWC vs. Observed Ens. Mean CIWC



(Li et al., 2011a, in preparation)

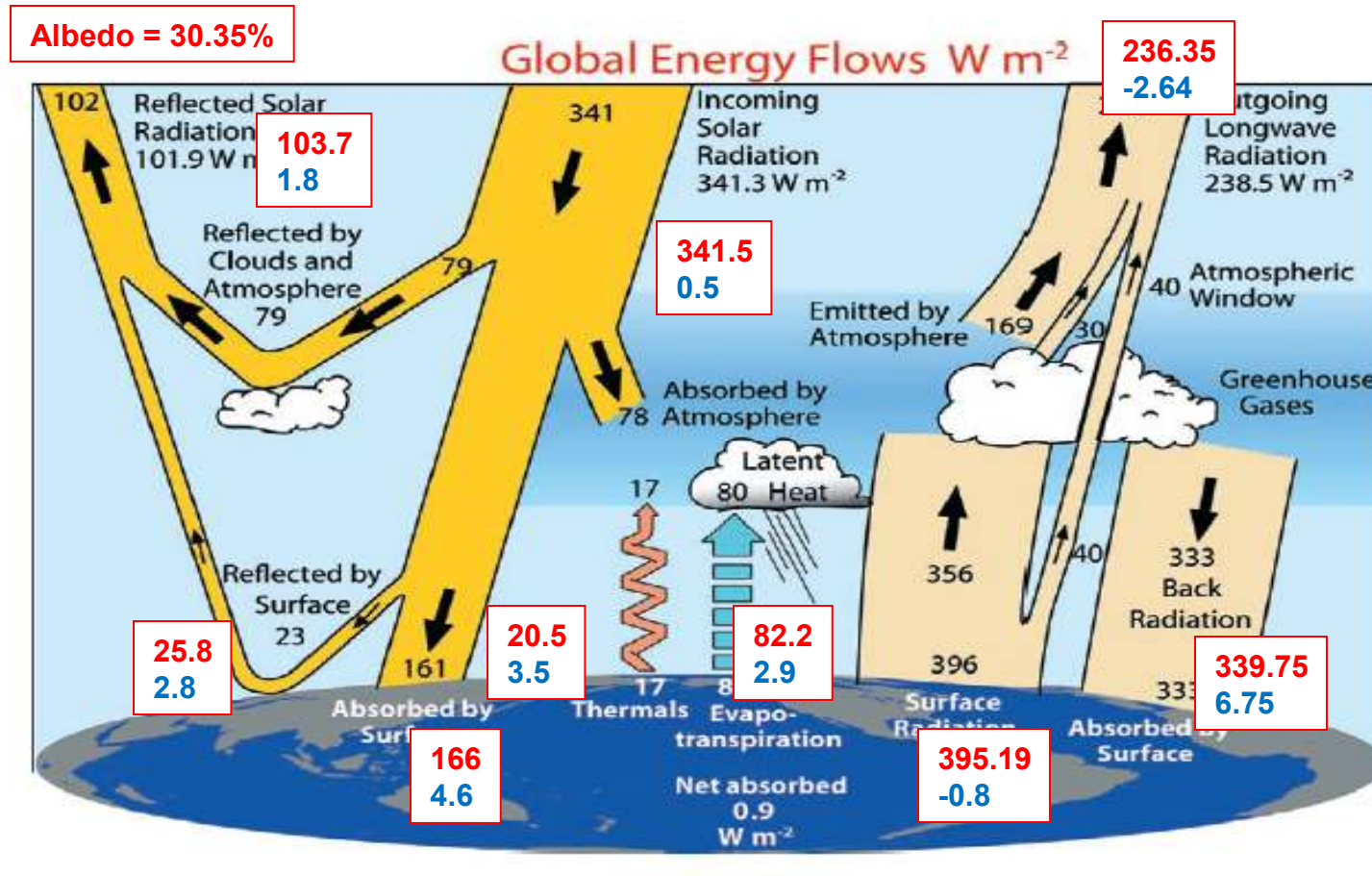
Zonally-averaged, annual mean values of CMIP5 and Observed CLWC



(Li et al., 2011b, in preparation)

Significant CIWC & CLWC biases are identified in CMIP3 and CMIP5 against Observed Cloud Ice & Liquid estimates.

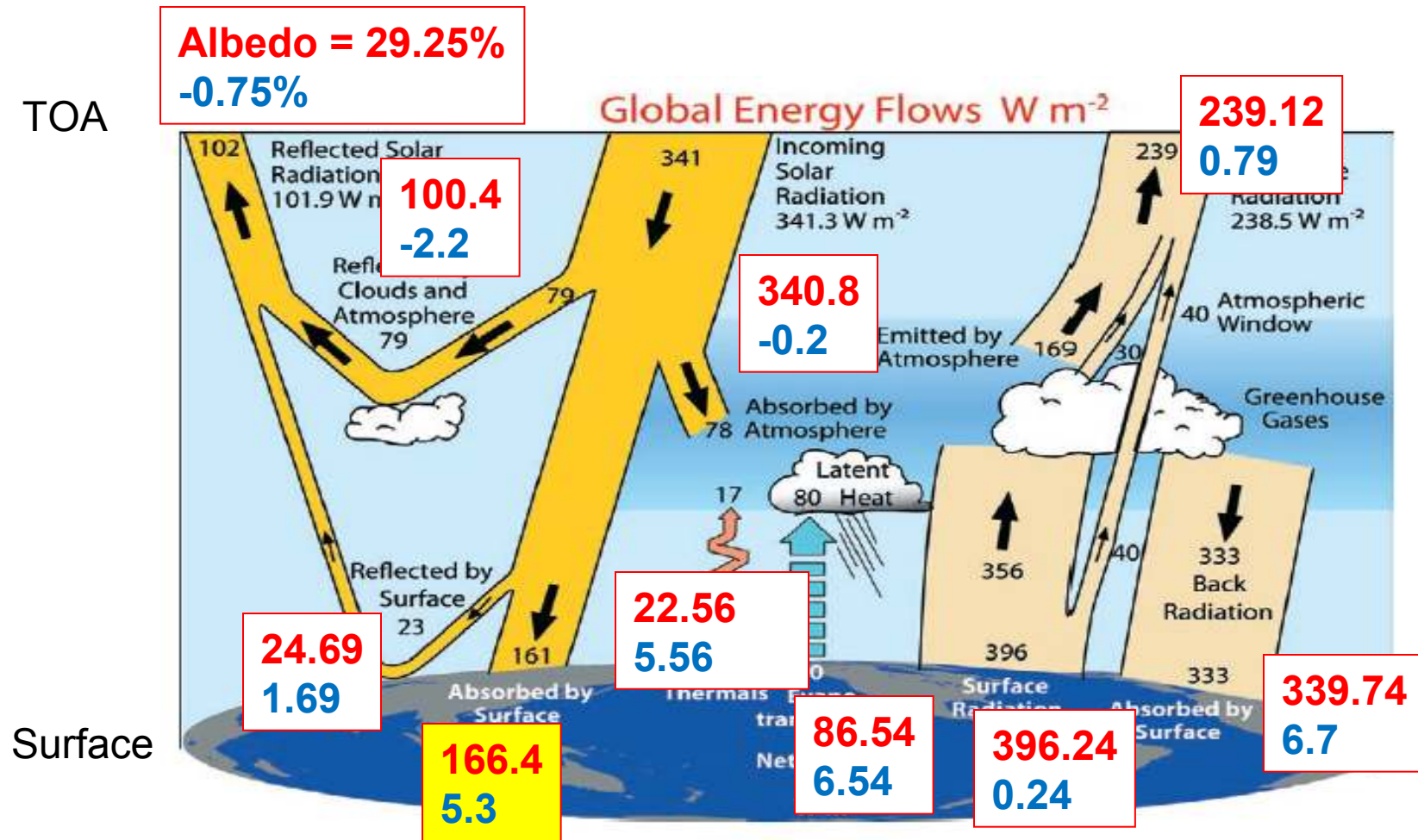
CMIP3(12) Present Day Global Annual Model Mean Budget



Blue: the difference between KT09

(Figure adopted from Trenberth et al, BAMS, 2009)

CMIP5 (11) Present Day Global Energy Budget



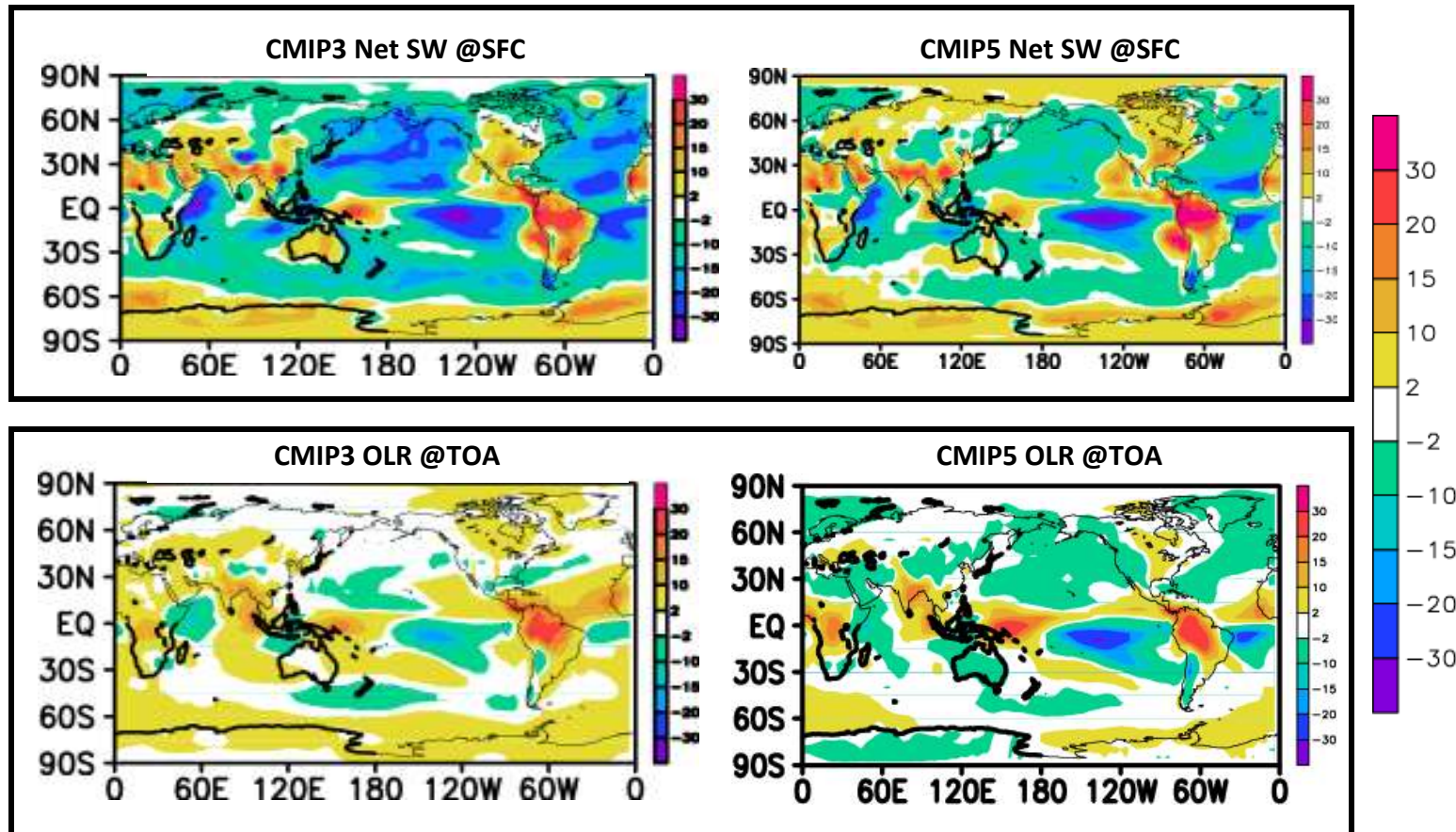
Blue: the difference between current study and Trenberth (2009) data

(Li et al., 2011c, in preparation)

(Figure adapted from Trenberth et al, BAMS, 2009)

Model Evaluation of Radiation for 20th Century IPCC AR 4th and 5th Simulations using Terra and Aqua CERES

Net SW
@Surface

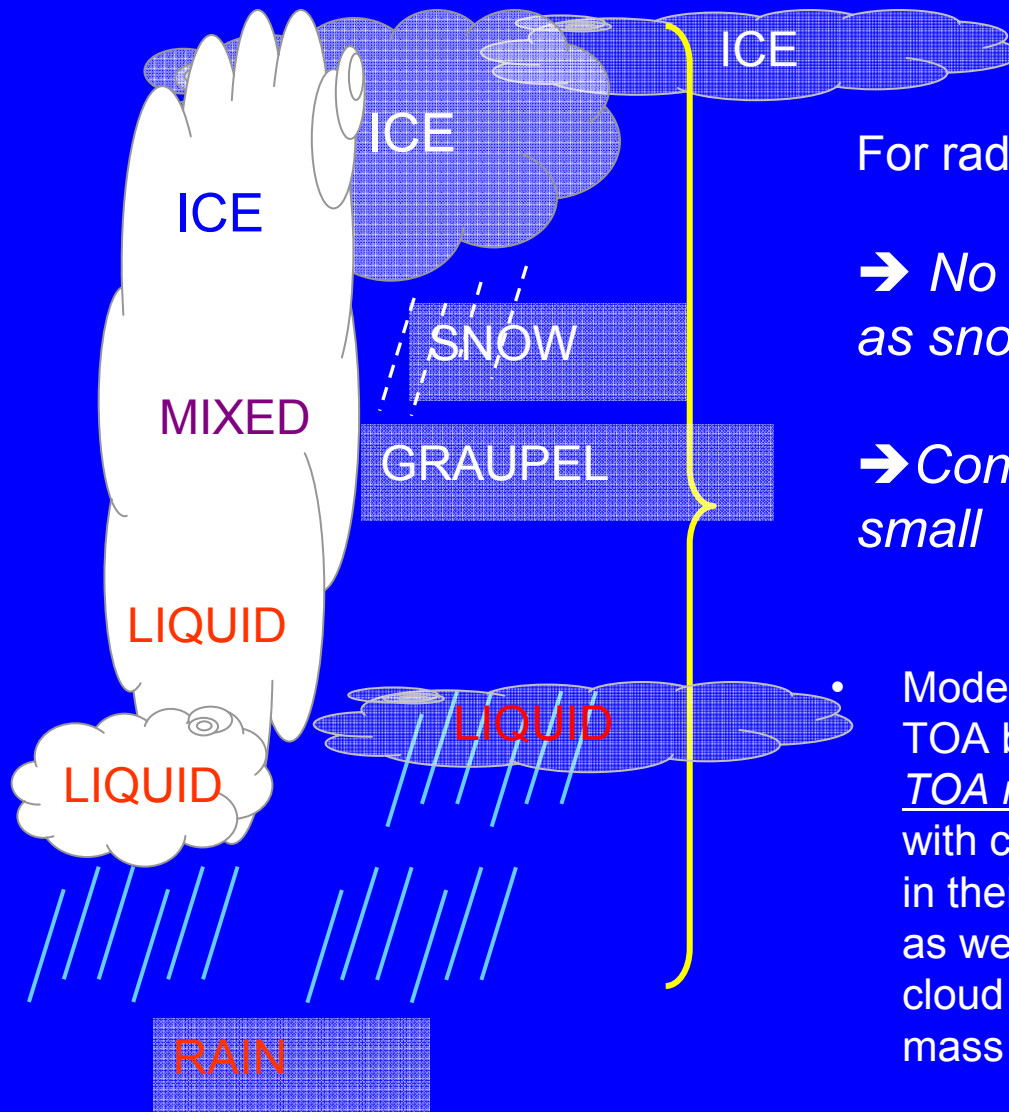


OLR
@TOA

Significant biases are identified in IPCC AR4/CMIP3 and AR5/CMIP5 with excessive surface SW and TOA LW fluxes over intense convective/precipitating regions.

(Li et al., 2011c, in preparation)

Issues of GCM specification of particle type and sizes for radiation calculations:



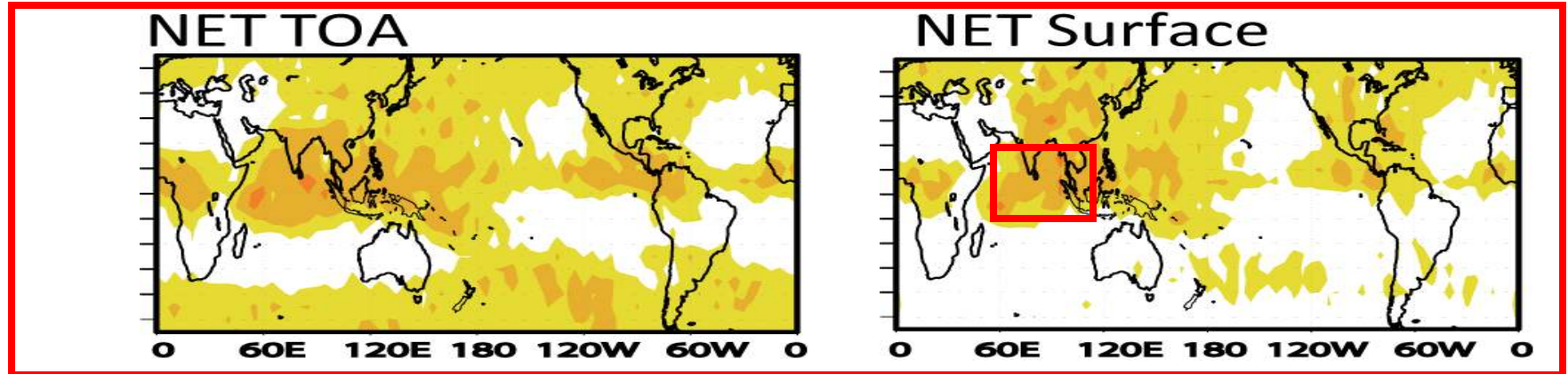
For radiation calculations, in many GCMs, :

→ *No prognostic larger particles such as snow, graupel and rain are included*

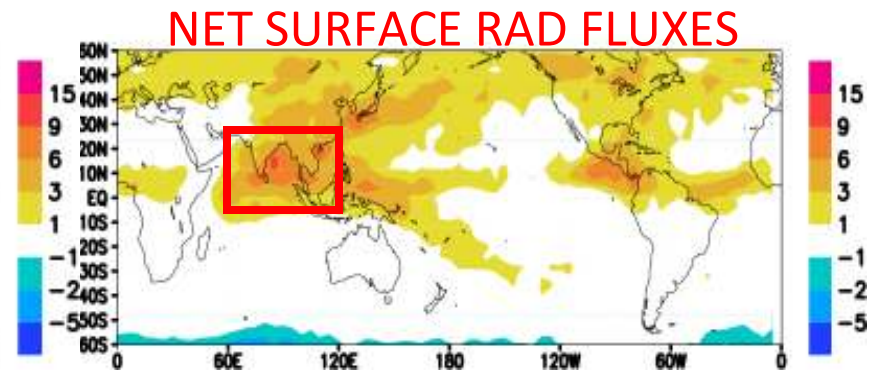
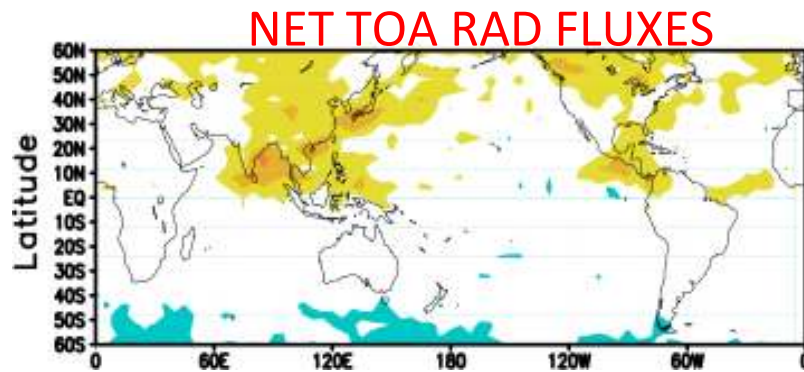
→ *Convection area thought to be too small*

- Models not accounting for this are getting TOA balance *incorrectly (i.e., tuning models' TOA radiative fluxes toward observations)* with compensating errors in radiative fluxes in their vertical distribution and at the surface as well as in quantities such as cloud cover, cloud particle effective radius and/or cloud mass AND/OR regional biases

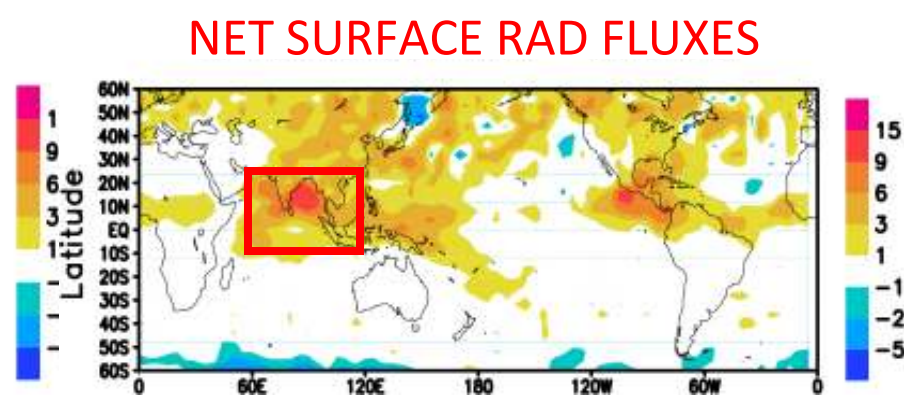
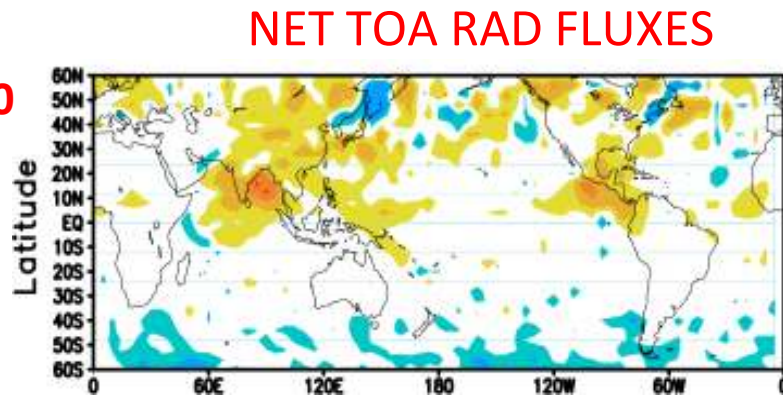
Net Radiative effects: No snow-radiation – Control(with)
CloudSat offline sensitivity test (Waliser et al., 2011)



EC FCST
24 to 48



EC FCST
120 to 240



(Li et al., 2011d, in preparation)

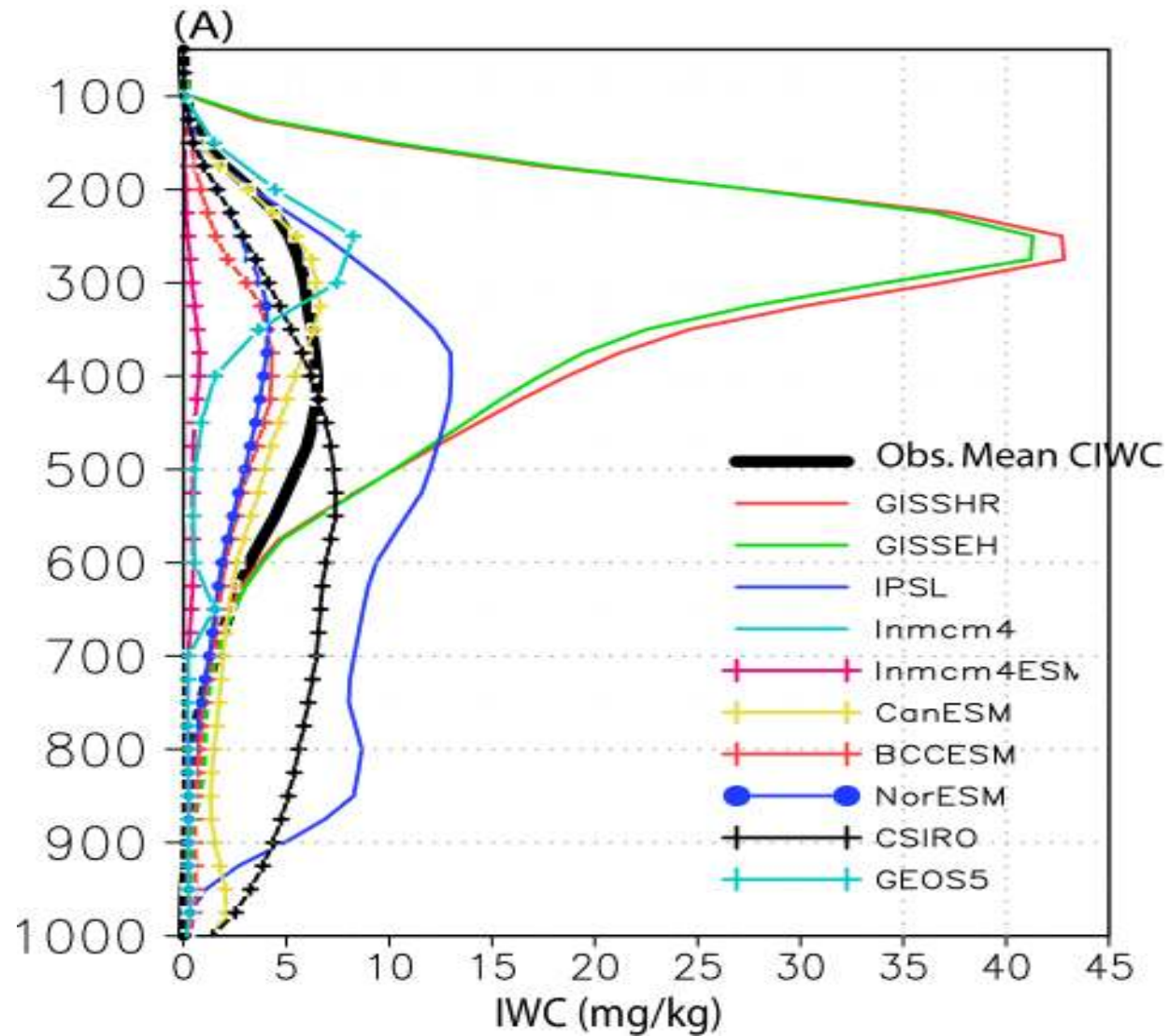
Result Highlights

- The comparison of IWC, LWC and radiation fields between CMIP3 and CMIP5 model fidelity using observed values shows no substantial improvement between the two successive model archives.
- Regional excessive OLR and net surface shortwave fluxes are evident over convective active regions from the annual mean values against CERES/SRB data, consistent with what was suggested in Waliser et. al. (2011) that such a bias might be caused by not treating the interaction of precipitation and/or convective core and with radiation in the models.
- Caution must be taken into account when making model-data comparisons related to cloud ice/liquid water content and their radiative fields if precipitating cloud is not represented in the models
- The above results appear robust when sensitivities to methods of precipitation vs cloud discrimination and IWP/LWP retrievals (e.g. CloudSat Radar only and/or Calipso-lidar combined) are considered.



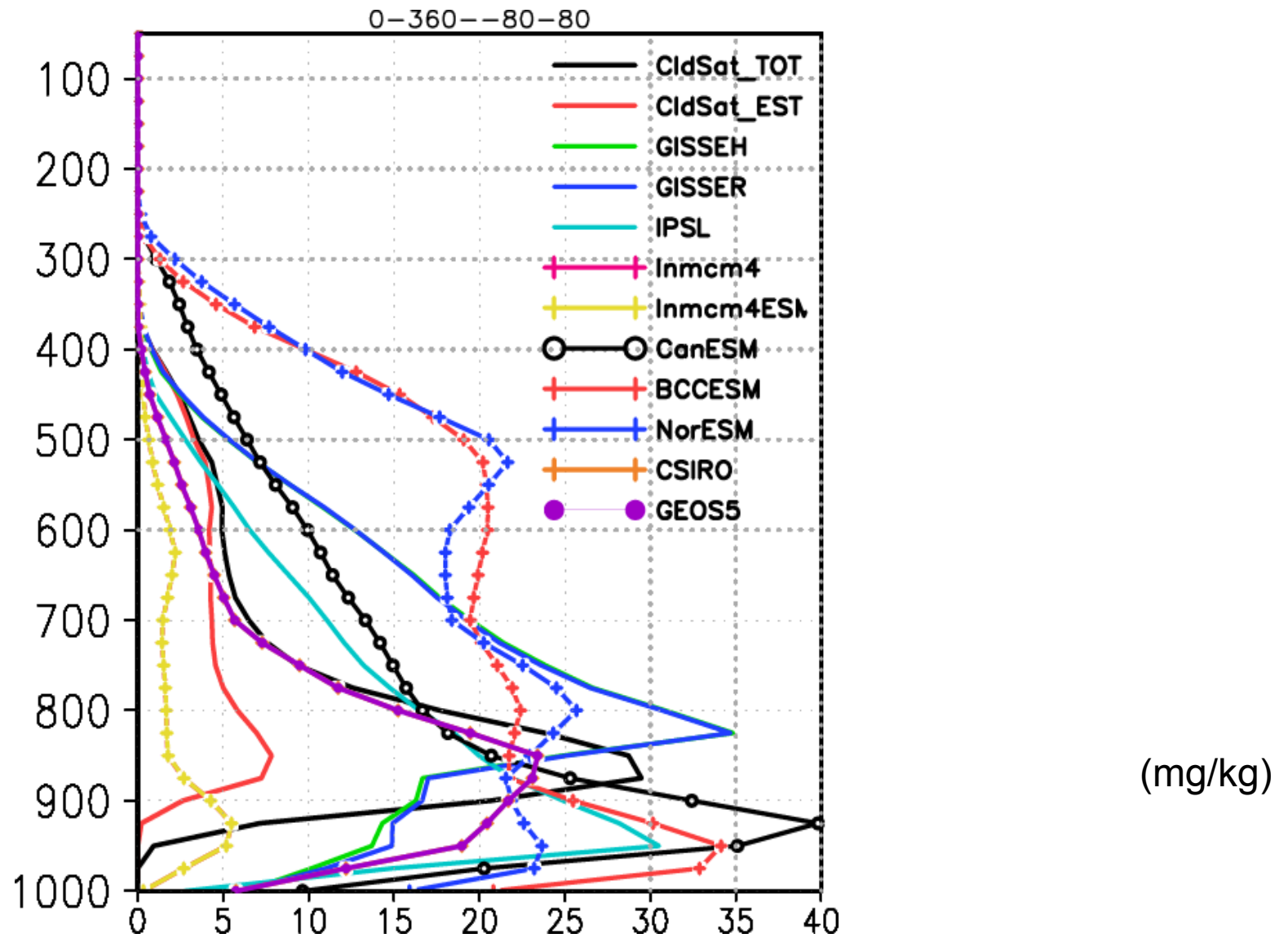
Thanks

Global Annual Mean CMIP5 CIWC vs. Observed Ens. Mean CIWC



(Li et al., 2011a, in preparation)

Global Area-Averaged, Annual Mean CMIP5 and Observed CLWC



(Li et al., 2011b, in preparation)